

Week – 4 – April 22, 2015

Application of Satellite Data to Particulate, Smoke and Dust Monitoring

Spring 2015

ARSET - AQ

Applied Remote Sensing Education and Training – Air Quality

A project of NASA Applied Sciences



Today's Speakers

Pawan Gupta

Research Scientist

NASA Goddard Space Flight Center/USRA

Email: pawan.gupta@nasa.gov

Website Demo: Ground Based Air Quality Monitors

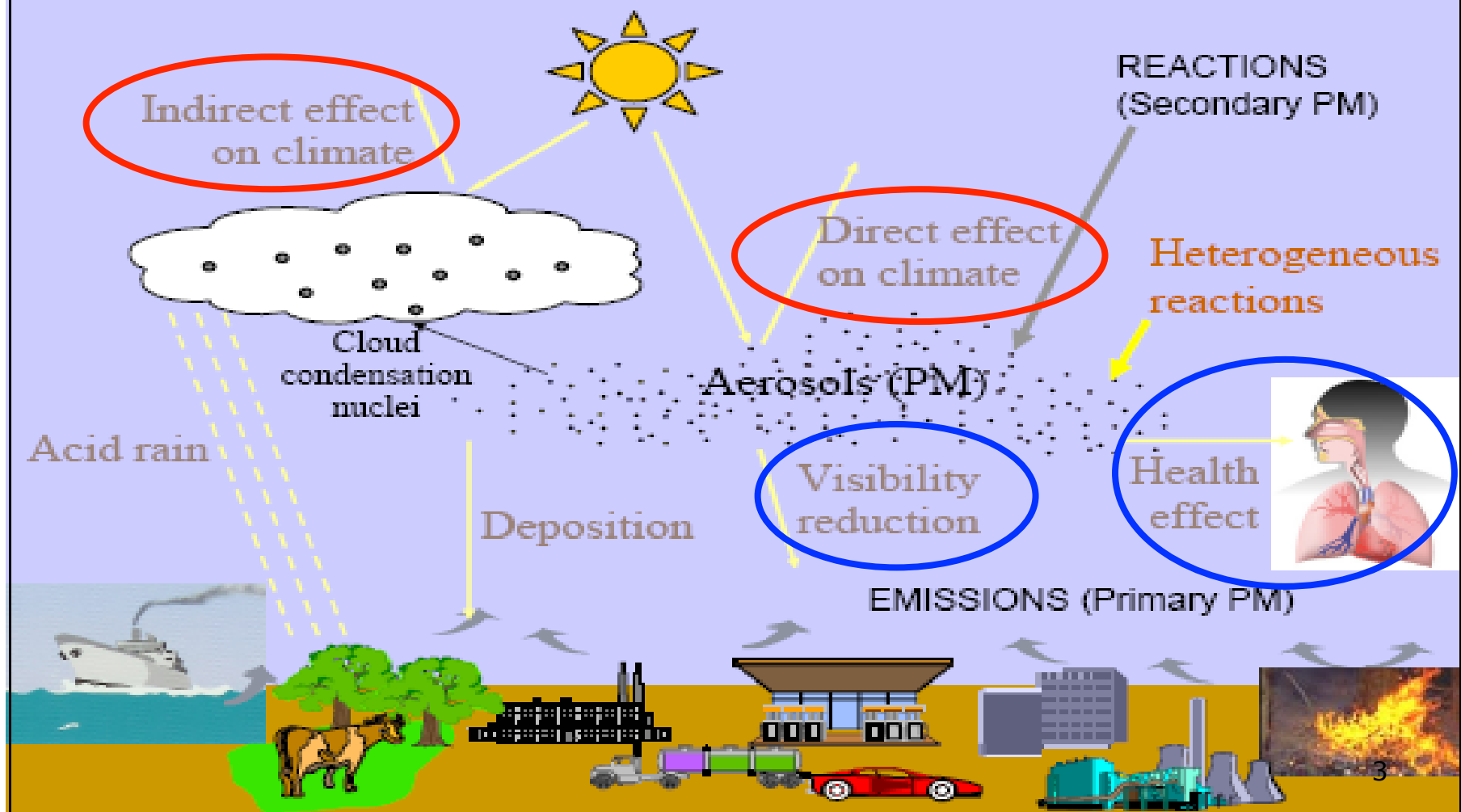
Ronan

Chief Scientist

Email: ron@aqicn.org

Motivation – tiny but Potent

Effects of Atmospheric Aerosols



Environmental Agencies & Public Looking for...

Index Values	Category	Cautionary Statements	PM _{2.5} (ug/m ³)	PM ₁₀ (ug/m ³)
0-50	Good	None	0-15.4	0-54
51-100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion	15.5-40.4	55-154
101-150	Unhealthy for Sensitive Groups	Sensitive groups should reduce prolonged or heavy exertion	40.5-65.4	155-254
151-200	Unhealthy	Sensitive groups should avoid prolonged or heavy exertion; everyone else should reduce prolonged or heavy exertion	65.5-150.4	255-354
201-300	Very Unhealthy	Sensitive groups should avoid all physical activity outdoors; everyone else should avoid prolonged or heavy exertion	150.5-250.4	355-424

Guidelines

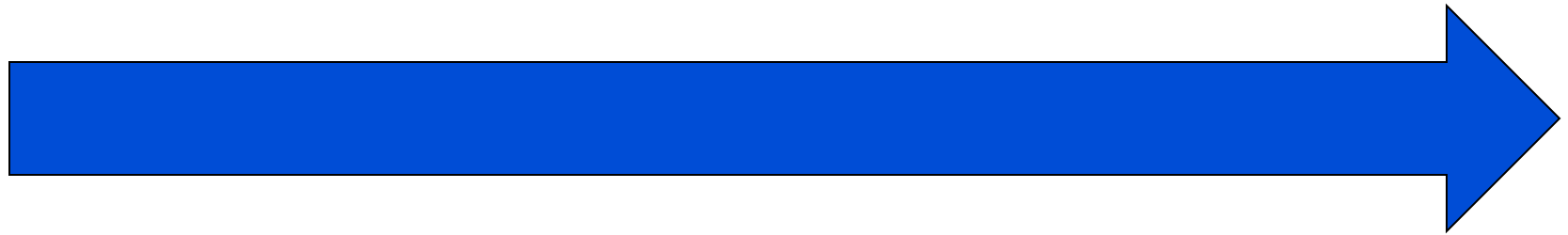
WHO

PM_{2.5}: 10 µg/m³ annual mean
25 µg/m³ 24-hour mean

India

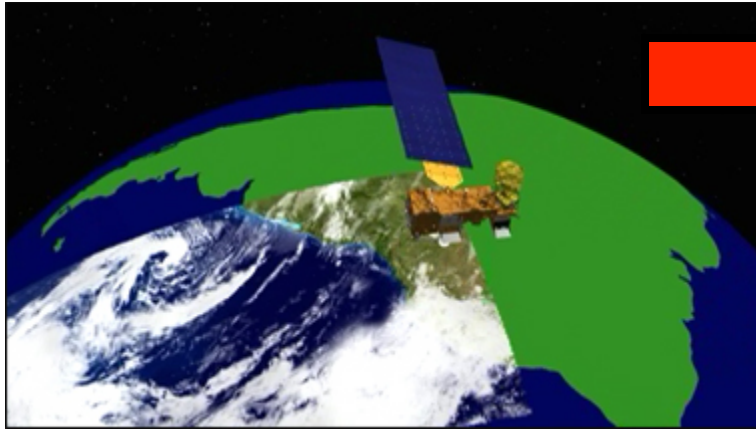
40 µgm⁻³ – Annual mean
60 µgm⁻³ – 24 hour mean

- Public
- Decision/Policy Makers
- Media
- Researchers



Column – to- Surface

Measurement Technique

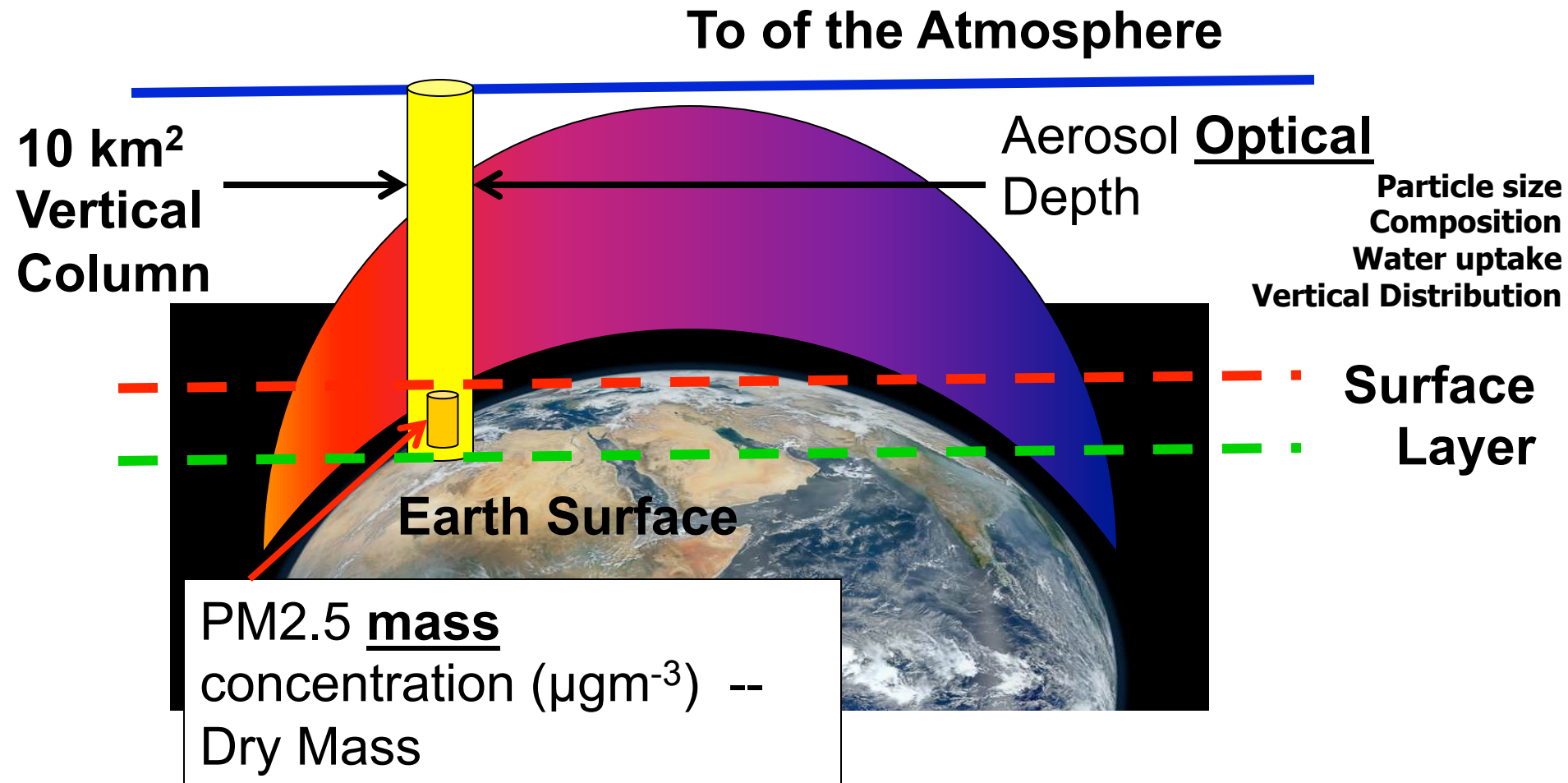


AOD – Column integrated value (top of the atmosphere to surface) - Optical measurement of aerosol loading – unit less. AOD is function of shape, size, type and number concentration of aerosols



PM_{2.5} – Mass per unit volume of aerosol particles less than 2.5 μm in aerodynamic diameter at surface (measurement height) level

What is our interest and what we get from satellite?



Surface Particulate Measurements vs Satellite Measurements of Aerosols

- Point vs Area Averaged**
- Surface vs Column**
- Mass vs Optical**

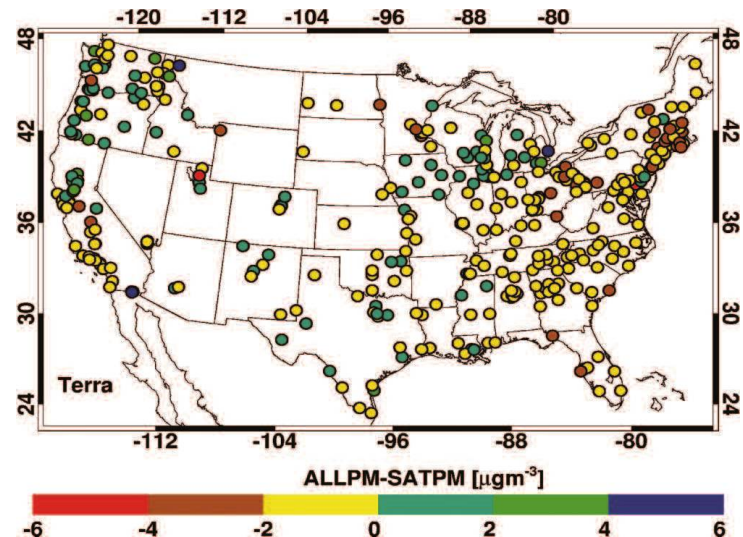
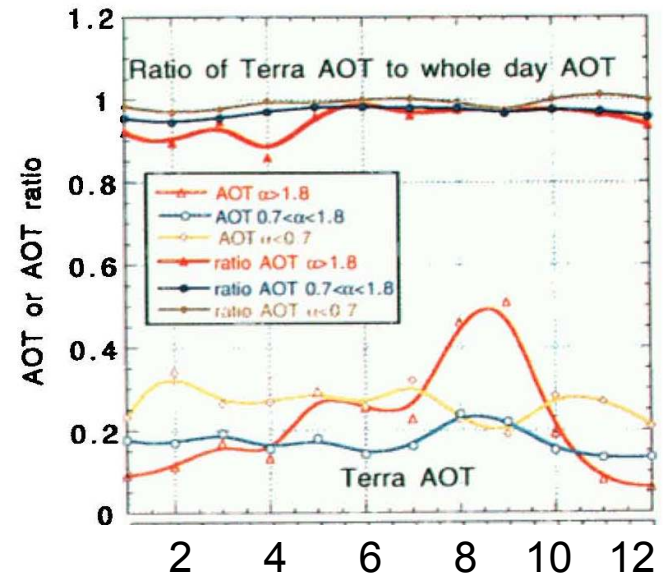
AOD to PM2.5 - Theoretical

$$AOD = PM_{2.5} H f(RH) \frac{3Q_{\text{ext,dry}}}{4\rho r_{\text{eff}}}$$

- AOD – Aerosol Optical Depth
- H – Height of well-mixed boundary layer
- f(RH) – Ratio of ambient and dry extinction coefficients
- p – Aerosol mass density
- Q – Mie extinction efficiency
- r – Particle effective radius
- PM2.5 – PM2.5 mass concentration

Support for AOD-PM_{2.5} Linkage

- Current satellite AOD is sensitive to PM_{2.5} (Kahn et al. 1998)
- Polar-orbiting satellites can represent at least daytime average aerosol loadings (Kaufman et al., 2000)
- Missing data due to cloud cover appear random in general (Christopher and Gupta, 2010)



AOD-PM Relationship

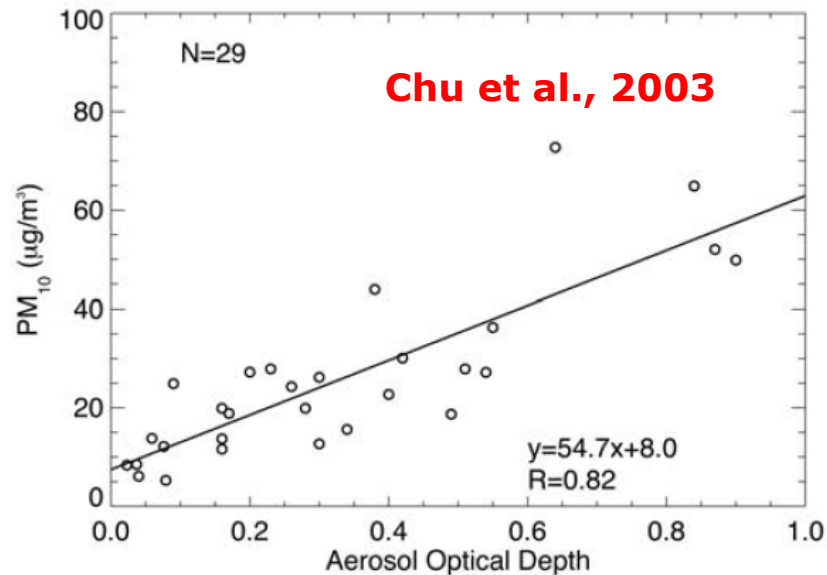
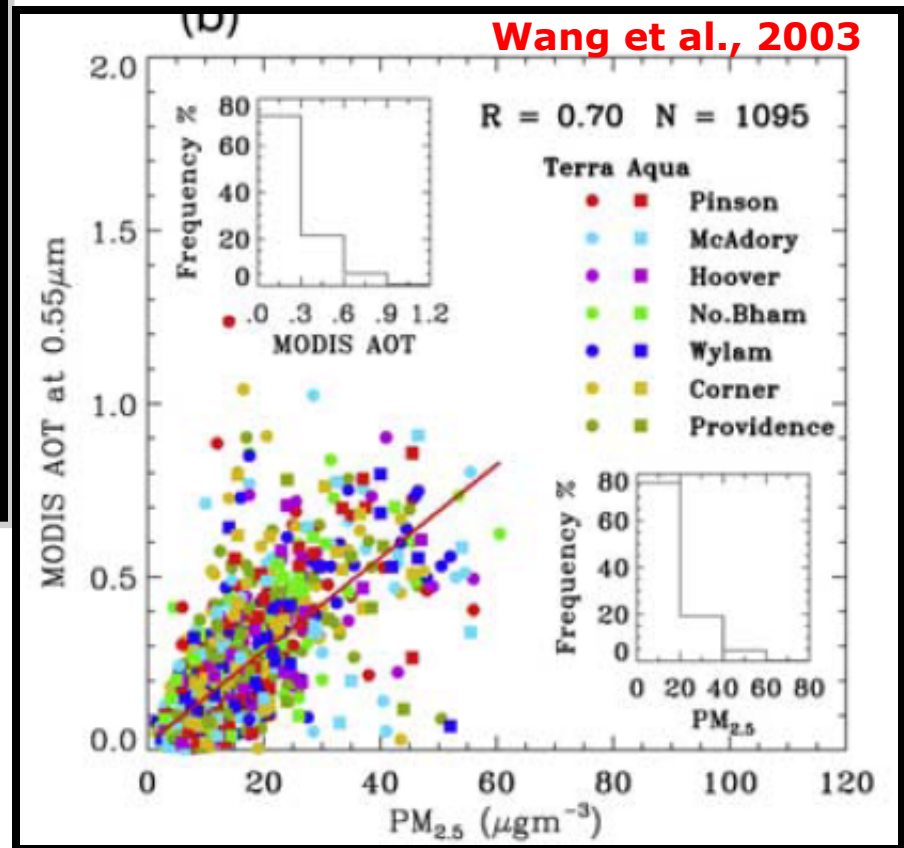
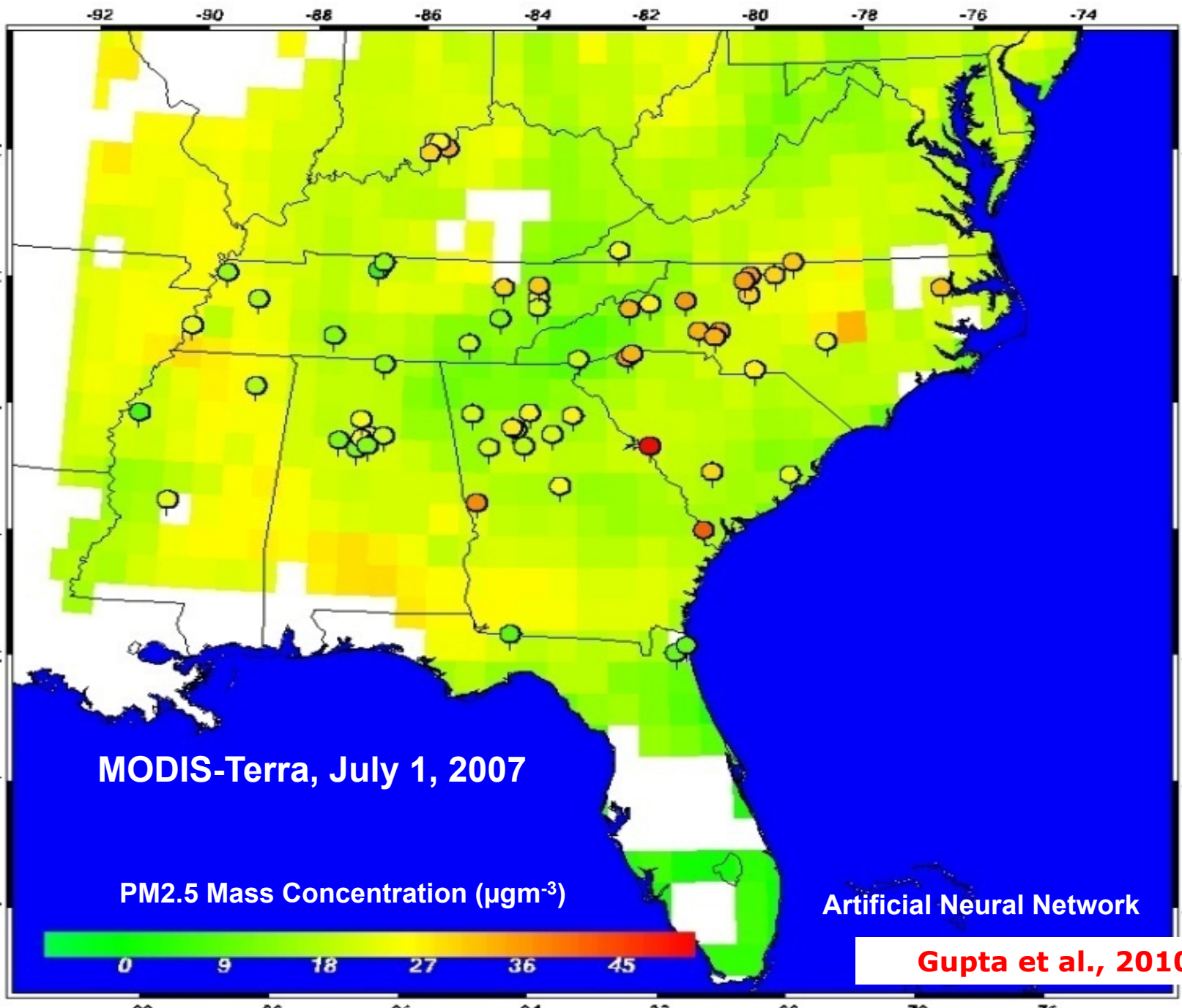


Figure 14. Relationship between 24-hour PM_{10} concentrations and daily averaged AERONET τ_a measurements from August to October 2000 in northern Italy.





Questions to Ask: Issues

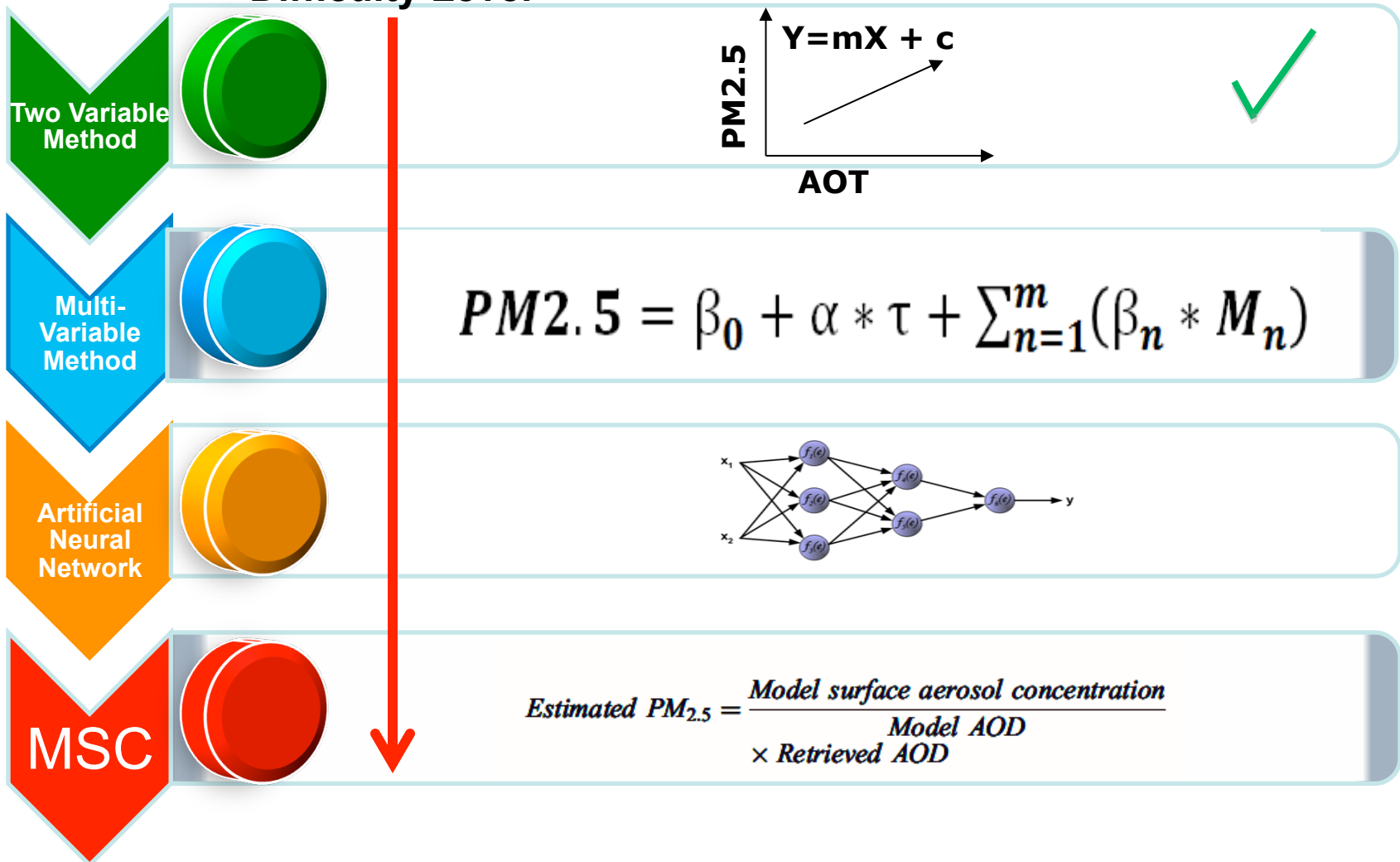
- ✓ How accurate are these estimations?
- ✓ Is PM_{2.5}-AOT relationship is always linear?
- ✓ How does uncertainty in AOT retrieval impact estimation of air quality
- ✓ Does this relationship change in space and time?
- ✓ Does this relationship change with a change in aerosol type?
- ✓ How does meteorology drive this relationship?
- ✓ How about vertical distribution of aerosols in the atmosphere?

Assumption for Quantitative Analysis

When most particles are concentrated and well mixed in the boundary layer, satellite AOD contains a strong signal of ground-level particle concentrations.

PM2.5 Estimation: Popular Methods

Difficulty Level

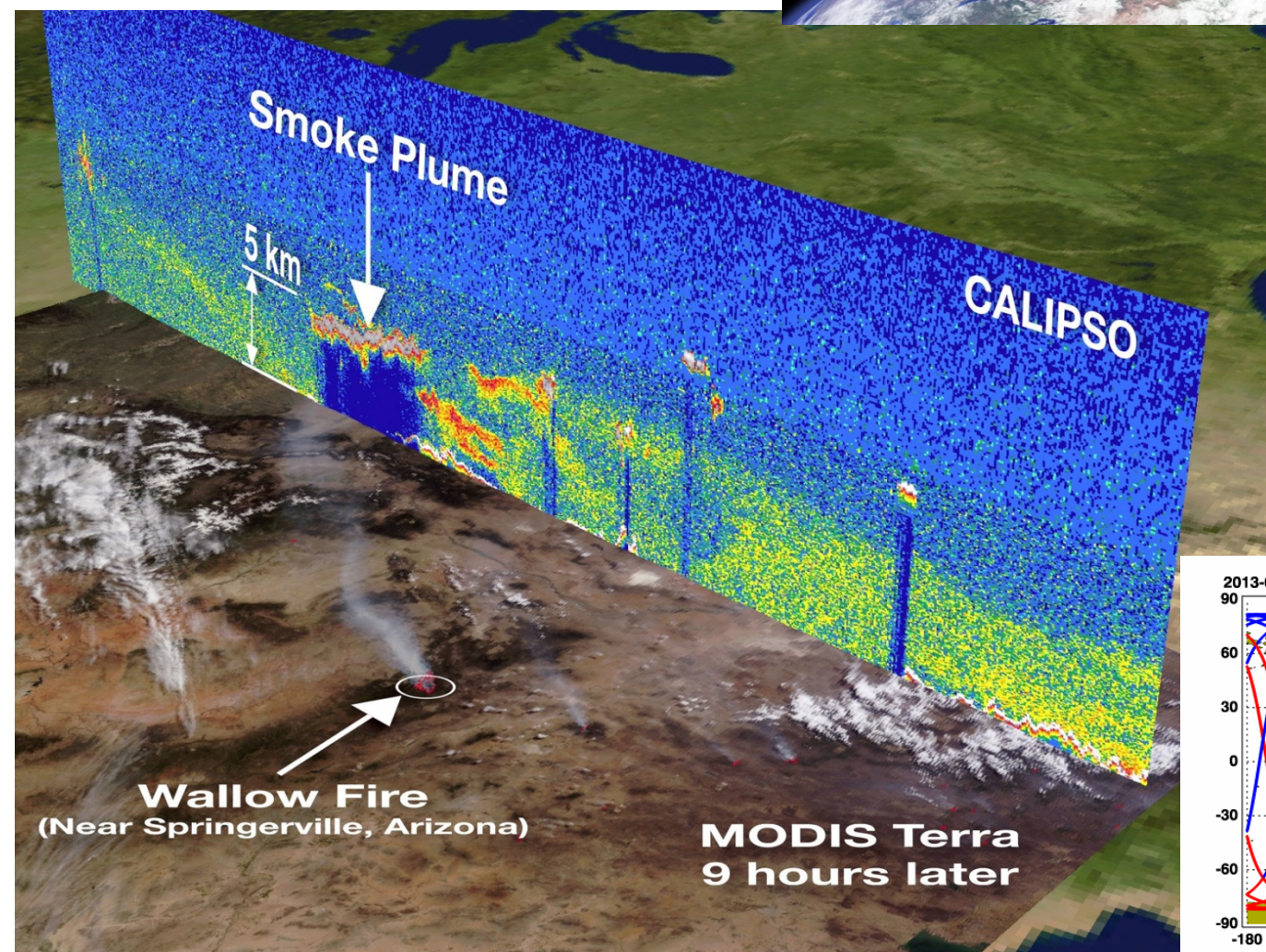
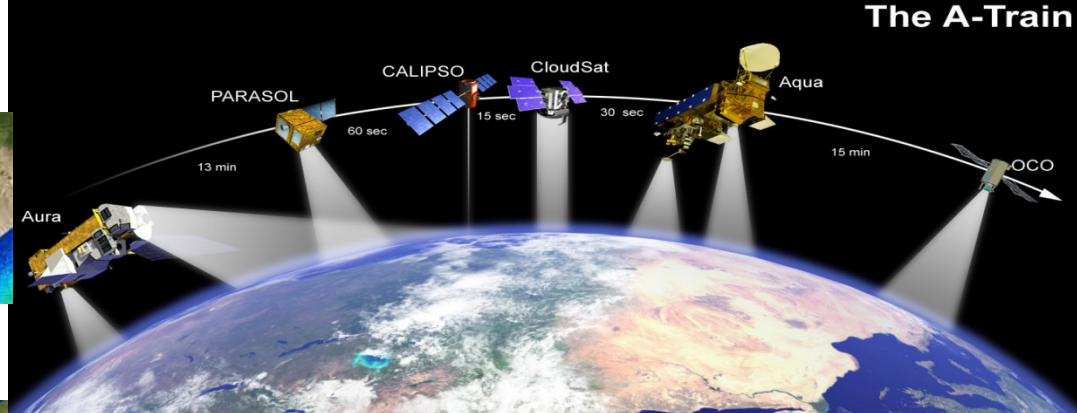
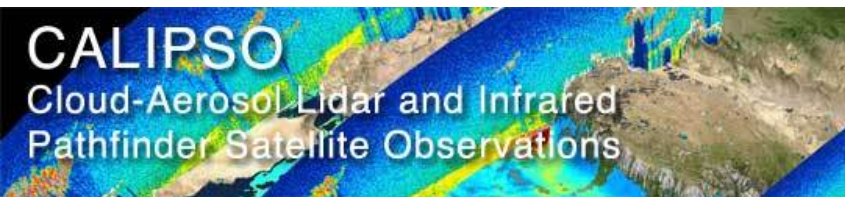


and Empirical Methods, Data Assimilation etc. are under utilized

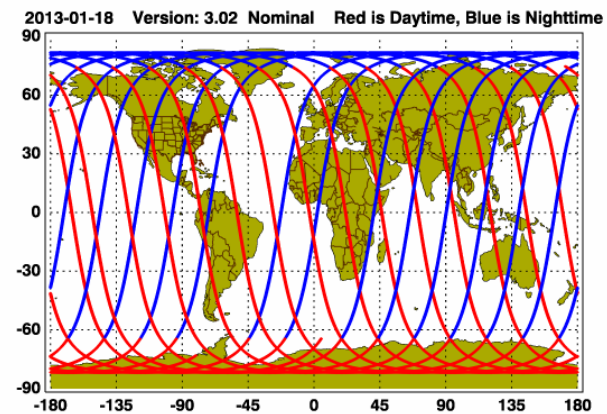
Modeling the Association of AOD With PM_{2.5}

- The relationship between AOD and PM_{2.5} depends on parameters that are hard to measure:
 - Vertical profile
 - Size distribution and composition
 - Diurnal variability
- We develop statistical models with variables to represent these parameters
 - Model simulated vertical profile
 - Meteorological & other surrogates
 - Average of multiple AOD measurements

No textbook solution!



**What Satellites
can provide on
vertical
information? -
CALIPSO**





R.M. Hoff



S.A. Christopher

Raymond M. Hoff

Department of Physics and the Joint Center for Earth Systems, Technology and Policy Center, University of Maryland, Baltimore

Sundar A. Christopher

ISSN:1047-3289 / Air & Waste
DOI:10.3155/1047-3289.59.6
Copyright 2009 Air & Waste Management Association

Remote Sensing of Particulate Pollution from Space: Hurdles and Promised Land

The use of the AOD as a measure for mass concentration has skill in some regions but less in others and does not provide a uniform way to measure aerosols across the United States. We discussed in Table 4 the range of mea-

standards (NAAQS).¹⁴² The 39-yr history of those standards parallels the time period that satellite meteorology and observations have developed and yet, to date, no satellite measurements have been used to quantitatively address the NAAQS. From the review conducted here, only one congress-

IMPLICATIONS

Satellite measurements are going to be an integral part of the Global Earth Observing System of Systems. Satellite measurements by themselves have a role in air quality studies but cannot stand alone as an observing system. Data assimilation of satellite and ground-based measurements into forecast models has synergy that aids all of these air quality tools.

ellite data possible in significant exceedances only. Applications such as event identification, transport, and atmospheric composition determination are strengths of satellite measurements. Where high precision is required (compliance monitoring, the "but for" test, and quantitative measurement of visibility effects on Class I areas), satellite data are presently of limited utility.

EPA has taken a satellite observations role for itself in the Exceptional Events Rule.¹⁴⁴ If a region can show conclusively that they are being impacted by an event (a fire, a dust storm, etc.) that is outside of their jurisdiction to regulate, the event can be flagged as a nonexceedance event. This provides a significant motivation for regional

Although the desire for the use of satellite data for air quality purposes is widely stated, the reality is that many of the measurements have not yet met the promise that they can be operationally used for today's air quality monitoring requirements. Precision in measuring AOD is

Dust & Smoke Monitoring Resources

- **RGB Images**
- **Aerosol Optical Depth**
- **Aerosol Index (OMI, OMPS)**
- **MISR coarse/fine mode AOD**
- **AIRS Dust Score**
- **AIRS CO**
- **AERONET**

Web Tool - Worldview

**An online visualization tool for the
near real time NASA data sets**

&

**Global Air Quality Monitoring System
(www.aqicn.org)**

Assignment – Week 4

<http://goo.gl/forms/EpU6ouPLf5>